

***Suisun Marsh Monitoring Program
Annual Data Summary***

Water Year 1999

Submitted in Fulfillment of:

Suisun Marsh Preservation Agreement

Suisun Marsh Monitoring Agreement

San Francisco Bay Conservation and Development Commission
Permit No. 35-78 (M) and 4-84 (M)

U.S. Army Corps of Engineers
Permit No. 16223E58, Special Condition 1

July 2001

State of California
Department of Water Resources
Environmental Services Office

List of Preparers

*This report was prepared by staff of the Department of Water Resources
Environmental Services Office*

Mike Bradbury Environmental Specialist IV
Liz Cook Environmental Specialist III
Cassandra Enos Environmental Specialist IV
Patty Finfrock Environmental Specialist III
Mike Floyd Senior Engineer WR
Dick Wada WR Engineering Associate

under the direction of

Kamyar Guivetchi. Supervising Engineer WR; Chief, Suisun Marsh Branch

with assistance from

Chris Alford Scientific Aid

and editing and publishing by

Lauren Buffaloe Research Writer

Introduction

This report summarizes data collected in the Suisun Marsh during Water Year 1999 (October 1, 1998 through September 30, 1999) pursuant to the following agreements, permits, and water rights decisions:

- State Water Resources Control Board Decision 1485, August 1978 (SWRCB 1978);
- State Water Resources Control Board Order WR 95-6, 1995 (SWRCB 1995a);
- Suisun Marsh Preservation Agreement, 1987 (USBR and others 1987);
- Suisun Marsh Monitoring Agreement, 1987 (DWR and others 1987);
- San Francisco Bay Conservation and Development Commission Permit No. 35-78 (M) Amendment 7, 1997 (for construction of the initial facilities, namely the Roaring River Distribution System, Morrow Island Distribution System, and Good-year Slough Outfall) (BCDC 1997);
- San Francisco Bay Conservation and Development Commission Permit No. 4-84 (M) Amendment 4, 1991 (for construction of the Suisun Marsh Salinity Control Gates) (1991); and,
- U.S. Army Corps of Engineers Permit No. 16223E58 (for construction of the Suisun Marsh Salinity Control Gates), Special Condition 1, 1986 (USACE 1986).

This report fulfills a portion of the annual reporting requirements of the above-listed, agreements, permits, and water rights decisions as detailed in Table 1. Remaining reporting requirements will be fulfilled in other Department of Water Resources (DWR) and/or University of California Davis reports.

DWR and the California Department of Fish and Game (DFG) primarily collected data summarized in this report. The data include

- general hydrologic data;
- continuous channel water specific conductance and tidal height measurements;
- marsh-wide vegetation survey update;
- waterfowl abundance; and
- salt marsh harvest mouse occurrence.

Table 1 Suisun Marsh reporting requirements covered in Department of Water Resources and/or University of California Davis reports

<i>Reporting information</i>	<i>Permit and/or agreement requiring information^b</i>	<i>SMMP^a data summary reports</i>	<i>Other DWR and/or UC Davis reports</i>
Monthly mean high tide salinity	SWRCB, SMMA	x	
SMHM surveys	USFWS BO	x	
Triennial vegetation surveys ^c	SMMA	x	
Waterfowl population surveys	SMMA	x	
Routine maintenance performed ^d	BCDC	x	
Maintenance scheduled for next year ^d	BCDC	x	
UC Davis fish sampling	SWRCB ^e , SMMA, USACE, BCDC		x
Larval fish survey	Not required ^f		x
Striped bass tow-net survey	SMMA, USACE, BCDC		x
Phytoplankton and <i>Neomysis</i> surveys	SMMA, BCDC		x
Striped bass egg and larva survey	SMMA, USACE, BCDC		x
Juvenile chinook salmon monitoring	SMMA, USACE, BCDC, NMFS		x
Predator sampling	SMMA, USACE, BCDC, NMFS		x
Adult salmon migration study	SMMA, USACE, BCDC, NMFS		x
Water quality profiling program	SWRCB ^e		x

^a Suisun Marsh Monitoring Program.

^b SWRCB: State Water Resources Control Board D-1485

SMMA: Suisun Marsh Monitoring Agreement (DWR and others 1987)

USFWS BO: U.S. Fish and Wildlife Service Biological Opinion 1-1-81-F-131

BCDC: San Francisco Bay Conservation and Development Commission Permits 35-78(m) and 4-84(m)

USACE: U.S. Army Corps of Engineers Permit 16223E58

NMFS: National Marine Fisheries Service 1993 Biological Opinion for Operation of the federal Central Valley Project and the California State Water Project.

^c Surveys are conducted and results reported every three years.

^d Covers DWR facilities in Suisun Marsh such as the water quality monitoring stations and the initial facilities.

^e Falls under D-1485 requirement to conduct special studies to develop a better understanding of the hydrodynamics, water quality, productivity and significant ecological interactions of the marsh.

^f The larval fish study is not required by any DWR permits. Data from this study provides a more complete picture of the Suisun Marsh fishery and provides additional information to help guide CEQA and ESA compliance for DWR projects.

Background

The Suisun Marsh is located about 35 miles northeast of San Francisco in southern Solano County (Figure 1). The Suisun Marsh is one of the largest brackish water marshes in the United States. It provides habitat for numerous species of plants, fish, and wildlife and is a critical component of the San Francisco Bay/Sacramento San-Joaquin Delta estuary.



Figure 1 Location of Suisun Marsh

DWR and the U.S. Bureau of Reclamation (USBR) store and divert water upstream of the Suisun Marsh. These and numerous other storage facilities and diversions can cause increased intrusion of saline water from San Francisco Bay to the Suisun Marsh and Delta during hydrologically dry periods.

The State Water Resources Control Board (SWRCB) adopted Water Rights Decision 1485 in 1978 to protect water quality in the Delta and the Suisun Marsh. This decision was recently superseded by SWRCB Decision 1641, which was adopted on December 29, 1999. Decision 1641 was subsequently amended and adopted as Order WR 2000-02 on March 15, 2000.

Several agreements have been developed between DWR, USBR, DFG, and Suisun Resource Conservation District (SRCD) to address SWRCB requirements for the protection of the Suisun Marsh. These agreements relate to monitoring salinity conditions in the marsh, as well as monitoring affects to wildlife and managed wetland operations. The agreements also cover the construction and operation of facilities for controlling salinity conditions in the marsh.

More detailed and specific background information on the Suisun Marsh and related monitoring programs is presented in the *Suisun Marsh Monitoring Program Reference Guide*. This guide is accessible on the Internet at <http://iep.water.ca.gov/suisun>. A copy of the guide is also available by request from DWR.

California Department of Water Resources
Environmental Services Office
3251 S Street
Sacramento, CA 95816-7017
Attn: Ken Minn

Data Summary

Hydrologic Conditions

Water Year Hydrologic Classification and Estimated Total Runoff for the Sacramento Valley

The Sacramento Valley Hydrologic Classification Index for water year 1999 is 9.75 million-acre feet (maf). Water years with indices greater than 9.2 maf are considered “wet years.” The method for calculating the Index and the water year classification system for the Sacramento Valley are described in Appendix A (page 20). The index calculation for water year 1999 is included in Appendix B (page 21).

Estimated total runoff from the Sacramento Valley watershed for water year 1999 is 21.03 maf. Table 2 lists water year classifications, estimated total runoff, and the water year index for the Sacramento Valley for water years 1990 through 1999.

Table 2 Sacramento Valley water year hydrologic classification data for water years 1990 through 1999

<i>Water year</i>	<i>Classification^a</i>	<i>Index^b</i>	<i>ETR^c (maf)</i>
1990	Critical	4.8	9.2
1991	Critical	4.2	8.4
1992	Critical	4.1	8.9
1993	Above Normal ^d	8.5	22.4
1994	Critical	5.0	7.8
1995	Wet	12.7	33.9
1996	Wet	10.2	22.2
1997	Wet	10.8	25.4
1998	Wet	13.3	31.4
1999	Wet	9.75	21.0

^a State Water Resources Control Board 1995 Water Quality Control Plan classification system.

^b Sacramento Valley water year classification Index.

^c Estimated total runoff using Sacramento Valley Four River Index in million acre-feet.

^d Water year 1993 is classified as an above normal wet year instead of a wet year because it followed a critically dry year.

Monthly Mean Net Delta Outflow Index

The Net Delta Outflow Index (NDOI) is the estimated daily rate of outflow from the Delta calculated in cubic feet per second (cfs). Monthly mean NDOIs are calculated by averaging all daily NDOIs for a given month. The method for calculating the daily NDOI is described in Appendix C (page 22).

Large amounts of precipitation fell in the Sacramento River watershed during February 1999. The monthly mean NDOI during water year 1999 peaked in February to 105,173 cfs, as listed in Table 3. With the exception of October through December, the monthly mean NDOIs for water year 1999 were significantly lower than the NDOIs for water year 1998. The relatively high NDOIs for October through December of water year 1999 were likely a result of the high precipitation and outflow that occurred during water year 1998, as well as significant precipitation that occurred in early water year 1999.

Table 3 Mean monthly Net Delta Outflow Index for water years 1998 and 1999

<i>Month</i>	<i>Net Delta Outflow Index (cubic feet per second)</i>	
	<i>1998</i>	<i>1999</i>
October	4,842	12,267
November	10,154	20,481
December	15,350	47,052
January	71,738	36,373
February	231,175	105,173
March	104,748	73,633
April	88,512	35,004
May	67,633	22,911
June	71,835	14,052
July	30,967	10,817
August	20,007	6,141
September	20,119	4,754

Precipitation

Precipitation data are collected at DFG headquarters on Grizzly Island in the Suisun Marsh. Total monthly precipitation data for water year 1999 are listed in Table 4. February was the wettest month during water year 1999. Rainfall during this month accounted for about 30% of the total rainfall in the marsh during water year 1999.

Table 4 Total monthly precipitation at Grizzly Island for water year 1999

<i>Month</i>	<i>Rainfall (inches)</i>
October	0.90
November	2.10
December	4.27
January	2.45
February	5.88
March	2.35
April	1.96
May	0.01
June	0.00
July	0.00
August	0.00
September	0.00
Total	19.92

Suisun Marsh Salinity Control Gates Operations

The operational status of the Suisun Marsh Salinity Control Gates (SMSCG) during water year 1999 is listed in Table 5. The purpose and operation of the SMSCG are described in Appendix D (page 24). During water year 1999, the gates were only operated for the purpose of conducting a special study, Evaluation of the Modification of the SMSCG on Adult Chinook Salmon Passage. This study is further discussed in Appendix D.

Table 5 Suisun Marsh Salinity Control Gates operational schedule during water year 1999

<i>Period</i>	<i>Operational status^a</i>	<i>Flashboard status</i>
Oct. 1, 1998 – Oct. 12, 1998	Operating	In place
Oct. 13, 1998 – Oct. 26, 1998	Open, not operating	Out ^b
Oct. 27, 1998 – Nov. 12, 1998	Operating	In place ^c
Nov. 13, 1998 – Feb. 2, 1999	Open, not operating	In place ^c
Feb. 3, 1999 – Feb. 3, 1999	Closed ^d	In place ^c
Feb. 4, 1999 – Apr. 6, 1999	Open, not operating	In place ^c
Apr. 7, 1999 – Aug. 31, 1999	Open, not operating	Out
Sept. 1, 1999 – Sept. 26, 1999	Operating	In place ^c
Sept. 27, 1999 – Sept. 30, 1999	Operating	In place

^a During water year 1999 the SMSCG were operated only for the purpose of conducting a study evaluating their effects on chinook salmon passage, not for salinity control.

^b Flashboards out for spacer fabrication.

^c Modified flashboards installed.

^d Gates closed from 1035 to 1407 hours for velocity test at flashboards.

Water Quality Conditions

All SWRCB channel water salinity standards for the Suisun Marsh were met in water year 1999, as shown in Table 6. The locations of the five compliance stations and two monitoring stations are illustrated in Figure 2. A detailed discussion of the data collection methods is available in the *Suisun Marsh Monitoring Program Reference Guide, Version 1* cited in the “Background” section.

Suisun Marsh channel water salinity standards for water year 1999 are specified by SWRCB Order WR 95-6 and are expressed in terms of specific electrical conductance (SC). Salinity conditions in the marsh are monitored by measuring SC levels. Additional information on the Suisun Marsh channel water standards for water year 1999 is presented in Appendix E (page 25).

Suisun Marsh channel water salinity conditions during water year 1999 were primarily a function of high Delta outflow. Monthly mean high-tide SC levels at the beginning of the 1999 water year compliance season (October 1998 through May 1999) were low. Heavy precipitation beginning in December 1998, followed by rapid increases in Delta outflow served to reduce marsh salinity levels, as illustrated by Figures 3 through 5. During the 1999 compliance season monthly mean high tide SC at all compliance stations remained far below SWRCB standards.

Table 6 Monthly mean high tide specific conductance (SC) at Suisun Marsh compliance stations and SWRCB standards (mS/cm)

<i>Month</i>	<i>Eastern stations</i>			<i>Western stations</i>		
	<i>C-2</i>	<i>S-64</i>	<i>S-49</i>	<i>S-42</i>	<i>S-21</i>	<i>Standard^a</i>
October	0.51	0.67	2.07	2.68	NA ^b	19.00
November	1.01	1.48	3.57	4.54	NA ^b	15.50
December	0.12 ^c	0.39	1.96	2.43	1.71 ^d	15.50
January	0.40	0.93	2.65	3.28	3.12	12.50
February	0.14	0.38	0.99	1.39	1.04	8.00
March	0.16	0.32	0.71	0.95	0.96	8.00
April	0.18	0.44	1.06	1.24	1.22	11.00
May	0.19	0.57	1.24	1.48	1.44	11.00

^a Specified by SWRCB Order WR 95-6.

^b SC data failed quality assurance/quality control analysis.

^c SC readings below reliable range of the instrumentation 12/5/98 through 12/29/98.

^d Value may be biased due to limited data caused by equipment and/or power failure occurring 12/1/98 through 12/11/98.

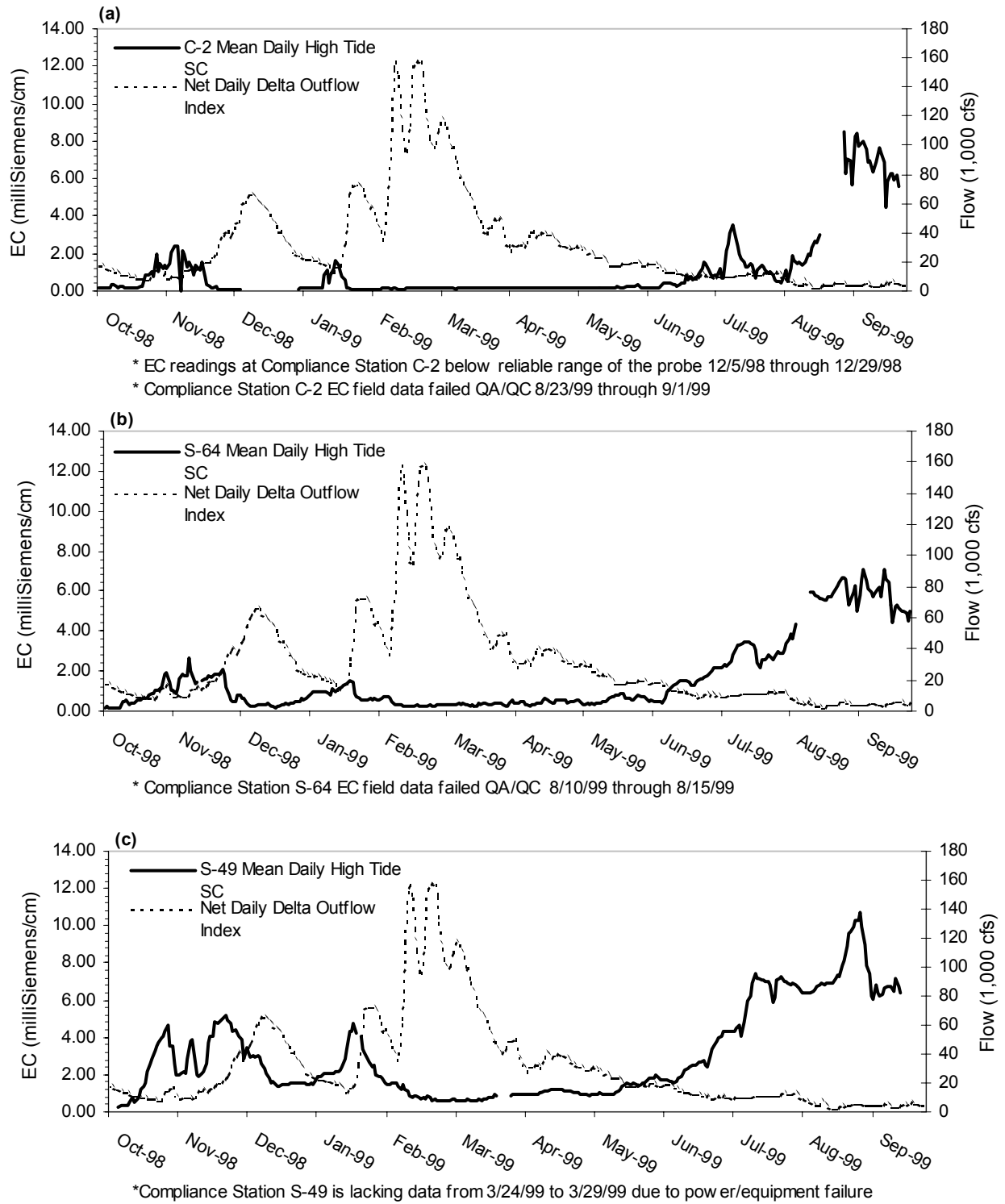


Figure 3 Specific electrical conductance and Net Delta Outflow for water year 1999 at compliance stations (a) C-2, (b) S-64, and (c) S-49

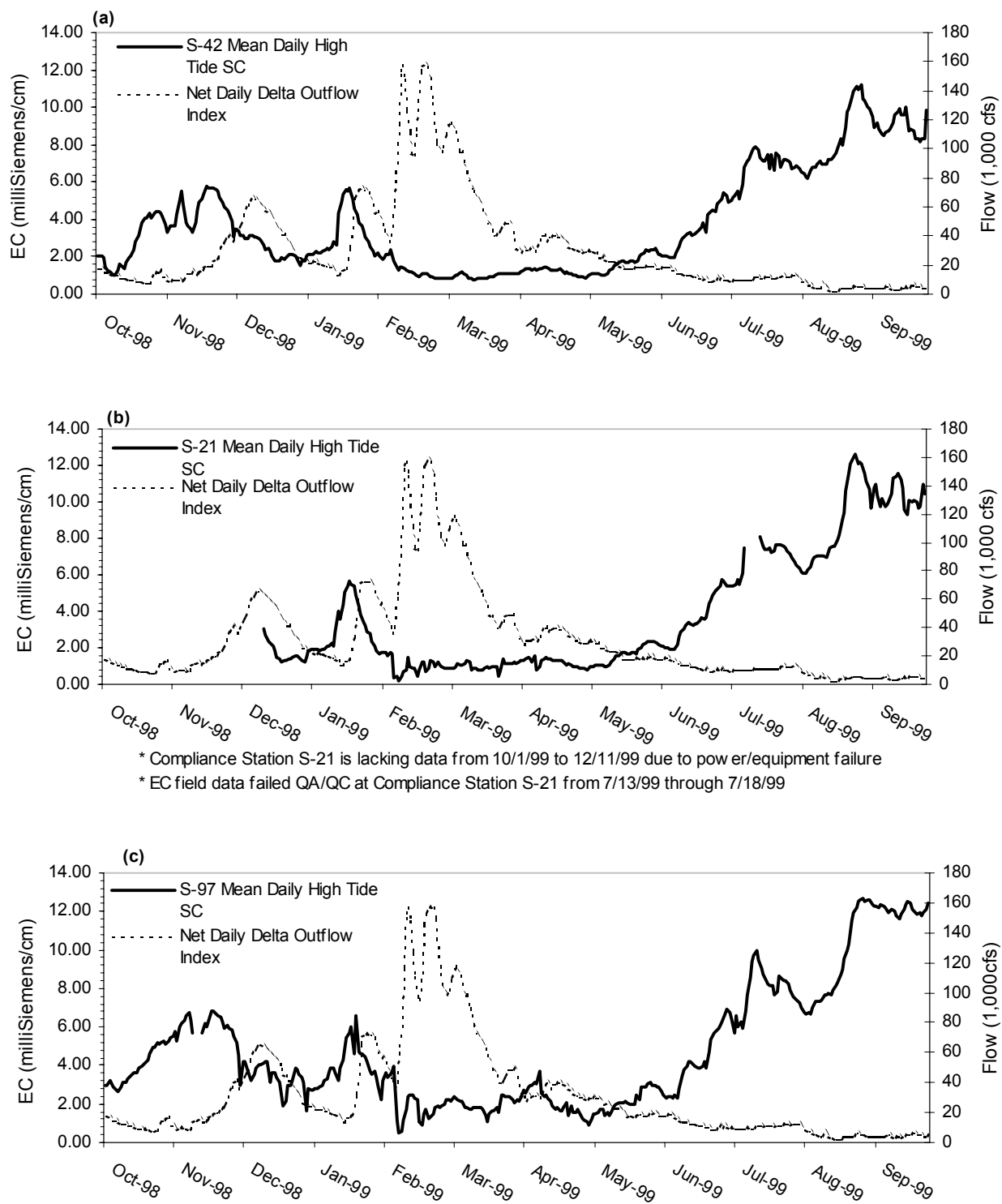


Figure 4 Specific electrical conductance and Net Delta Outflow for water year 1999 at compliance stations (a) S-42, (b) S-21, and (c) monitoring station S-97

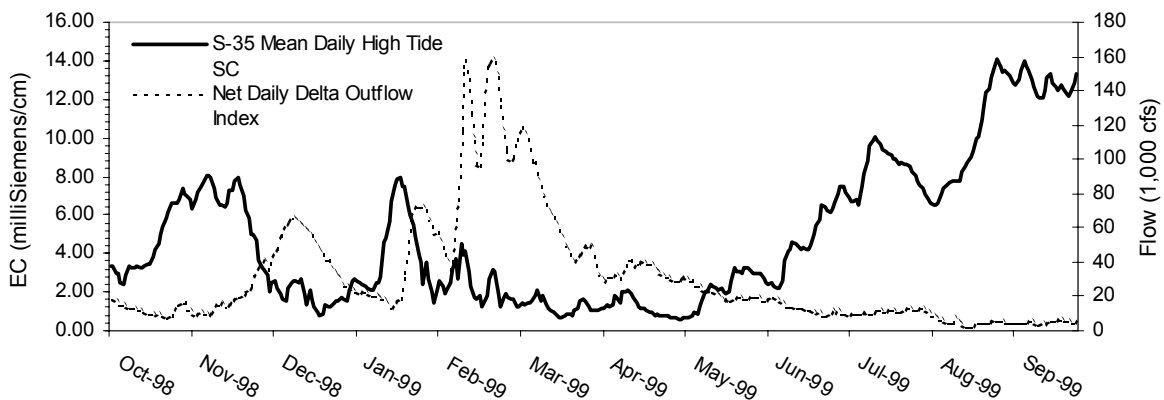


Figure 5 Specific electrical conductance and Net Delta Outflow for water year 1999 at monitoring station S-35

Monthly mean high-tide channel water SC levels were lower at eastern marsh compliance stations than at western marsh compliance stations during most months of the 1999 water year compliance season. Eastern marsh stations are identified as those east of the confluence of Cutoff and Montezuma sloughs (S-64 and S-49) and those on the Sacramento River near the confluence with Montezuma Slough (C-2). Western marsh stations are those located west of the confluence of Cutoff and Montezuma sloughs (S-42 and S-21).

Salinity levels in the eastern portion of the Suisun Marsh are typically lower than levels in the western marsh largely because of the proximity of the eastern Marsh to the Sacramento River and Delta. The station closest to the Delta (C-2) had the lowest monthly mean high tide salinity levels throughout the compliance season. Monthly mean high tide salinity levels at S-49, the westernmost of the eastern marsh stations, were consistently higher than those recorded at either C-2 or S-64.

Station S-49 in the eastern marsh had a higher SC value (1.96 mS/cm) than station S-21 in the western marsh (1.71 mS/cm) during December 1999. This may have been due, in part, to increased inflow from Suisun Creek during periods of high rainfall, along with increased surface runoff and outflow in Green Valley Creek and Suisun Slough. A levee breach occurred along the north side of Frank Horan Slough near S-21, on August 8, 1999. The breach remained open throughout the remainder of the 1999 water year. This breach may have further resulted in lower salinity levels by helping “trap” fresher water flowing out of Suisun Creek. In addition, limited data for S-21 during December 1999 may have resulted in biased data during this period.

Monthly mean high-tide salinity levels at the western *monitoring* stations, S-35 and S-97 (Table 7) were generally higher than the five compliance stations. This was probably due to their close proximity to Suisun Bay and their extreme westernmost positions in the marsh (Figure 2) where influence from Delta outflow is low.

Table 7 Monthly mean high tide specific electrical conductance at two Suisun Marsh monitoring stations (mS/cm)

<i>Month</i>	<i>S-97</i>	<i>S-35</i>
October	4.00	4.52
November	5.96	6.20
December	3.36	1.81
January	3.95	4.17
February	2.03	2.45
March	1.97	1.28
April	2.20	1.24
May	1.97	1.89

Wildlife

Salt Marsh Harvest Mouse Monitoring

Fourteen areas in the Suisun Marsh were surveyed for presence of the salt marsh harvest mouse (SMHM) during water year 1999. Five of the fourteen areas are conservation areas originally selected as preferred SMHM habitat by DFG in fulfillment of the U.S. Fish and Wildlife Service's (USFWS) 1981 Biological Opinion for the Suisun Marsh Management Plan. Eight of the fourteen surveyed areas were proposed in 1999 as additional conservation areas for the SMHM. The final surveyed area is located at Rush Ranch, which is owned by the Solano County Open Space Foundation. This area was primarily used as a training site. Background information on the SMHM monitoring program is included in Appendix F (page 27).

Species captured during water year 1999 include SMHM, other small rodents, and shrews (Table 8). SMHM were captured at all fourteen areas, and capture rates were often quite high relative to previous years' surveys. Capture rates during water year 1998, which followed widespread flooding, were unusually low. The success of the 1999 surveys indicates that the SMHM can quickly recover from such events.

In addition to the above trapping efforts, SMHM surveys were conducted at the Island Slough Pond 7 mitigation area. One hundred acres on Island Slough have been set aside and managed as SMHM habitat to meet the mitigation requirements for construction of the physical facilities, which were mandated in the Suisun Marsh Plan of Protection. Trapping results at Island Slough are included in Table 8.

Table 8 Results of SMHM surveys in the Suisun Marsh, June-September 1999

<i>Trapping location</i>	<i>Trap-nights</i>	<i>SMHM^a</i>	<i>unknown HM^b</i>	<i>Mus^c</i>	<i>Vole</i>	<i>SMHM capture rated</i>	<i>Other species captured</i>
Benicia Industrial	120	10 +1	2	6	4	0.08	7 shrews
Crescent	210	31 + 6	2	2	1	0.15	
Hill Slough West, Pond 1	220	27	5	9	1	0.12	
Rush Ranch	140	1	1	7	1	0.007	1 WHM ^e
Pond 12F	170	34+11	20+3	6+2	1	0.22	1 WHM
Area 11	100	22	10			0.22	
Red House Road	200	27	38	31		0.13	
Area 12	200	21+7	15+1	9		0.10	
Hill Slough East	300	1		57+15		0.003	1 WHM
Joice Island	500	5	12	120+36	1	0.01	24+4 WHM, 1 shrew
Pond 1	500	8+4		94+34		0.02	1 WHM
Hill Slough West, Area 4A	300	15+1	7+1	52	1	0.05	
Hill Slough East, Area 9	300	23+7	18+2	32	3	0.08	
Goodyear Slough	284	18+11	11+6	26+4	3	0.06	
Island Slough, Pond 7	300	23+9	5	37	1	0.08	

^a Numbers denote number of individual SMHM captured plus number of recaptures.

^b Unknown HM = unidentified harvest mouse, data were ambiguous or insufficient to determine *Reithrodontomys* species.

^c Mus = house mouse, *Mus musculus*.

^d SMHM capture rate = number of individual SMHM divided by number of trapnights.

^e WHM = western harvest mouse, *Reithrodontomys megalotis*.

During the water year 1999 trapping, a substantial number of mice were captured with characteristics intermediate between the western and salt marsh harvest mice. These mice were classified as “unknown harvest mice.” The lack of confidence in species identification and the implications of competition between the two harvest mouse species have created interest in conducting a study of harvest mouse genetics.

Waterfowl

The DFG conducted aerial waterfowl population surveys in the Suisun Marsh from September 1998 through January 1999. The results of the surveys are shown in Table 9. Summarized census estimates are included for northern pintail, mallards, all ducks combined, and all waterfowl combined. Northern pintail and mallards are the more common waterfowl species found in Suisun Marsh, and thus are listed separately as indicators of overall relative annual waterfowl abundance. Background information on waterfowl surveys in the Suisun Marsh is presented in Appendix G (page 30).

Table 9 Waterfowl counted in Suisun Marsh during water year 1999 and average numbers counted from 1990 through 1998

<i>Month</i>	<i>Mallard</i>	<i>Northern Pintail</i>	<i>Total Ducks^a</i>	<i>Total Waterfowl^b</i>
Numbers Observed for Water Year 1999				
September	7,190	1,705	14,410	17,170
October	21,972	9,800	53,624	63,054
November	5,758	15,946	52,479	59,186
December	14,855	29,845	95,560	102,830
January	7,120	6,745	53,365	64,781
Average Numbers Observed for Water Years 1990 through 1998 ^c				
September	4,510	6,490	15,600	16,000
October	16,720	31,580	86,770	84,620
November	12,600	30,990	83,620	90,190
December	13,350	34,530	115,740	125,200
January	10,860	21,200	74,550	88,960

^a Includes all species of ducks observed in Suisun Marsh during the survey period.

^b Includes all species of waterfowl observed in Suisun Marsh during the survey period.

^c November and December are actually only 9-year averages, since data from November 1994 and December 1992 are not available.

With few exceptions, surveys in water year 1999 had lower bird counts than the 1990 through 1999 average. The lower bird counts may be related to an 8% decline seen in the 1998 nesting waterfowl population.

Vegetation

A new vegetation mapping methods developed by DFG was approved by the Suisun Marsh Preservation Agreement Environmental Coordination Advisory Team during April 1999. The new methods are designed to document changes in preferred habitat for the salt marsh harvest mouse and gather vegetation data in such a way that it can be used for a variety of other purposes. The methods follow a standardized protocol used by the National Park Service and U.S. Geological Survey. The methods are described in *The Vegetation Survey for the Suisun Marsh, A New Methodology*.

Aerial photos of the marsh were taken in June 1999. In July 1999, DFG began photo interpretation and GIS scanning and registration. Between August and October 1999, DFG conducted vegetation sampling at randomly selected vegetation plots throughout the marsh. A final report and vegetation map was completed on December 30, 2000.

Maintenance

Monitoring Station Maintenance

Routine monitoring station maintenance in the Suisun Marsh during water year 1999 included flushing accumulated sediments from several tide wells, clearing accumulated vegetation from around monitoring stations, and repairing and resetting the staff gages at the Collinsville (C-2), Sunrise (S-21), and Volanti (S-42) stations. All polystyrene probe floats were replaced with open-cell type plastic foam floats. Worn and lost floats were also replaced.

Other station maintenance activities included reinforcing and modifying the walkway and building supports at National Steel (S-64), repairing the stilling well at Collinsville (C-2), and installing new platform decking at Beldons (S-49). The walkway at Ibis (S-97) was rebuilt and a pressure transducer was installed for data collection. Use of the stilling well was discontinued because of soil stability problems at the station. A new recorder housing was installed at Godfather II (S-37).

Staff removed several discontinued soil tube and pond stage recorder sites on individual ownerships. Discontinued SC monitoring sites at Morrow Drain (A-52), Mallard (A-60), Grizzly King Intake (A-68), and Hollywood (S-20) were removed.

Distribution System Maintenance

Morrow Island Distribution System

The north M-Line levee road of the Morrow Island Distribution System (MIDS) was widened and the C-Line outfall was modified during the summer of 1999. The north levee road was widened to a minimum of 12 feet from an average of about 11 feet, to meet facility specifications. The widening was accomplished by filling out an existing shelf on the land-side levee slope. No wetlands or other sensitive habitat or species were affected by the widening effort. The footprint of the levee remained as it was.

The C-Line outfall was modified by straightening the previously constructed wing-walls. The wing-walls support the outfall culverts and flapgates. Siltation has been problematic and continues to plague the facility. A plan to permanently correct the problem is being developed.

Planning for the installation of fish screens for the MIDS continued. The screens are a requirement of a USACE permit for dredging of the MIDS that occurred during 1997. Various fish screen configurations for the MIDS were developed by DWR. Regulatory agencies were consulted to select the most appropriate fish screen configuration(s) for the facility and surrounding managed wetlands. The goal of the selection effort was to identify an alternative that would protect sensitive fisheries in the most economical and environmentally sensitive manner available.

Roaring River Distribution System

Repairs were completed on sections of the Roaring River Distribution System (RRDS) levees to restore the levee system to the design specifications. The required environmental documentation for the repairs was obtained by June 1999. The contractor began work on the levees on July 14, 1999; work was completed on August 31, 1999. Repairs consisted of

- installation of Geofoam cores at two levee sites;
- raising levees to their original design elevations;
- widening levee roads to a minimum width of about 15 feet;
- placing aggregate base on most of the north and south levee roads; and,
- placing rip-rap on erosion prone banks.

The DWR Division of Engineering made their final inspection of the repairs on September 1, 1999, and subsequently gave final project approval. A Notice of Completion was sent to the regulatory agencies on September 13, 1999.

References

- [DFG] California Department of Fish and Game. 1999. Unpublished data, Wildlife Management Division.
- [DFG] California Department of Fish and Game. 1999. The vegetation survey for the Suisun Marsh, proposal for a new methodology [internal report]. Sacramento (CA): California Department of Fish and Game, Wildlife and Habitat Data Analysis Branch. 7 p + appendices.
- [DWR] California Department of Water Resources. 1984. Plan of protection for the Suisun Marsh including Environmental Impact Report. Sacramento (CA): California Department of Water Resources. 176 p + appendices.
- [DWR and others] California Department of Water Resources, California Department of Fish and Game, U.S. Bureau of Reclamation. 1987. Suisun Marsh Monitoring Agreement. March 2, 1987. 8 p.
- [BCDC] San Francisco Bay Conservation and Development Commission. 1997. Marsh development permit 35-78(M). Issued March 13, 1979, as amended through June 24, 1997. 10 p.
- [BCDC] San Francisco Bay Conservation and Development Commission. 1991. Marsh development permit 4-84(M). Issued March 13, 1979, as amended through June 27, 1997. 28 p.
- [SWRCB] State Water Resources Control Board. 1978. Water Right Decision 1485 for the Sacramento San-Joaquin Delta and Suisun Marsh. Sacramento (CA): State Water Resources Control Board. 44 p.
- [SWRCB] State Water Resources Control Board. 1995a. Order WR 95-6. Sacramento (CA): State Water Resources Control Board. 56 p.
- [SWRCB] State Water Resources Control Board. 1995b. Water Quality Control Plan for the San Francisco Bay/Sacramento San-Joaquin Delta Estuary.
- [USACE] U.S. Army Corps of Engineers. 1986. Regional General Permit No. 16223E58. San Francisco District, Regulatory Functions Branch.
- [USBR and others] U.S. Bureau of Reclamation, California Department of Water Resources, California Department of Fish and Game, and Suisun Resource Conservation District. 1987. Suisun Marsh Preservation Agreement, March 2, 1987. 15 p.
- [USFWS] U.S. Fish and Wildlife Service. 1987. Standard operating procedures for aerial survey of waterfowl and habitats on the breeding grounds in North America. Co-op U.S. Fish and Wildlife Service and Canadian Wildlife Service. 95 p.
- [USFWS] U.S. Fish and Wildlife Service. 1984. Salt marsh harvest mouse and California clapper rail recovery plan. Portland (OR): U.S. Fish and Wildlife Service. 141 p.
- Wernette F. 1987. Plan to manage 1,000 acres of DFG lands in the Suisun Marsh for the salt marsh harvest mouse [interagency memorandum dated June 19, 1987]. Stockton (CA): Department of Fish and Game, Bay Delta and Special Water Projects Division.

Appendix A

Method for Determining Water Year Hydrologic Classification for the Sacramento Valley

The water year hydrologic classification for the Sacramento Valley was determined following the method outlined in the SWRCB 1995 *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (SWRCB 1995). The Index for the Sacramento Valley is calculated as follows:

$$\text{INDEX} = 0.4X + 0.3Y + 0.3Z$$

Where:

X = Subject year's April through July Sacramento Valley unimpaired runoff;

Y = Subject year's October through March Sacramento Valley unimpaired runoff;

Z = Previous year's index¹

Sacramento Valley unimpaired runoff is defined in the SWRCB plan as follows:

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir.

The year type is determined based on the Index value, as shown in Table A-1. The year type for the preceding water year remains in effect until the initial forecast of unimpaired runoff for the current water year is available.

Table A-1 Determination of year type based on Index value

<i>Classification</i>	<i>Runoff Index (million acre-feet)</i>
Wet	Equal or greater than 9.2
Above Normal	Greater than 7.8 and less than 9.2
Below Normal	Equal to or less than 7.8 and greater than 6.5
Dry	Equal to or less than 6.5 and greater than 5.4
Critical	Equal to or less than 5.4

1. A cap of 10.0 maf is put on the previous year's index (Z) to account for required flood control reservoir releases during wet years.

Appendix B

Sacramento Valley Water Year 1999 Hydrologic Classification

The following equation was used to calculate the Sacramento Valley Hydrologic Classification for water year 1999:

$$\text{Index} = 0.4X + 0.3Y + 0.3Z$$

Where:

Index = Index for water year 1999 (maf)

X = April 1999 - July 1999 Sacramento Valley unimpaired runoff (maf).

Y = October 1998 - March 1999 Sacramento Valley unimpaired runoff (maf).

Z = Previous water year's Index (maximum allowable value for Z is 10.0 maf).

The calculation for water year 1999 is:

$$X = 7.20 \text{ maf}$$

$$Y = 12.91 \text{ maf}$$

$$Z = 10.0 \text{ maf}$$

$$\text{Index} = 0.4(7.20 \text{ maf}) + 0.3(12.91 \text{ maf}) + 0.3(10.00 \text{ maf}) = 9.75 \text{ maf}$$

Based on an Index value of 9.75 maf, water year 1999 is classified as a wet year.

Appendix C

Method for Calculating the Net Daily Outflow Index

The NDOI was determined following the method in the SWRCB 1995 *Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* (SWRCB 1995). The NDOI is computed daily using the following formulas (all flows are in cfs):

$$\text{NDOI} = \text{DELTA INFLOW} - \text{NET DELTA CONSUMPTIVE USE} - \text{DELTA EXPORTS}$$

Where $\text{DELTA INFLOW} = \text{SAC} + \text{SRTP} + \text{YOLO} + \text{EAST} + \text{MISC} + \text{SJR}$

SAC = Sacramento River at Freeport mean daily flow for the previous day; the 25-hour tidal cycle measurements from 12:00 midnight to 1:00 a.m. may be used instead.

SRTP = Sacramento Regional Treatment Plant average daily discharge for the previous week.

YOLO = Yolo Bypass mean daily flow for the previous day, which is equal to the flows from the Sacramento Weir, Fremont Weir, Cache Creek and Rumsey, and the South Fork of Putah Creek.

EAST = Eastside Streams mean daily flow for the previous day from the Mokelumne River at Woodbridge, Cosumnes River at Michigan Bar, and Calaveras River at Bellota.

MISC = Combined mean daily flow for the previous day of Bear Creek, Dry Creek, Stockton Diverting Canal, French Camp Slough, Marsh Creek, and Morrison Creek.

SJR = San Joaquin River flow at Vernalis, mean daily flow for the previous day.

Where $\text{NET DELTA CONSUMPTIVE USE} = \text{GDELP} - \text{PREC}$

GDELP = Delta gross channel depletion for the previous day based on water year type using the DWR's latest Delta land use study.¹

PREC = Real-time Delta precipitation runoff for the previous day estimated from stations within the Delta.

1. DWR is currently developing new channel depletion estimates. If these new estimates are not available, DAY-FLOW channel depletion estimates shall be used.

and Where $\text{DELTA EXPORTS}^1 = \text{CCF} + \text{TPP} + \text{CCC} + \text{NBA}$

CCF = Clifton Court Forebay inflow for the current day.²

TPP = Tracy Pumping Plant pumping for the current day.

CCC = Contra Costa Canal pumping for the current day.

NBA = North Bay Aqueduct pumping for the current day.

1. The term “Delta Exports” is used only to calculate the NDOI. It is not intended to distinguish among the listed diversions with respect to eligibility for protection under the area of origin provisions of the California Water Code.

2. Actual Byron-Bethany Irrigation District withdrawals from Clifton Court Forebay shall be subtracted from Clifton Court Forebay inflow. (Byron Bethany Irrigation District water use is incorporated into the GDEPL term.)

Appendix D

Purpose and Operation of the Suisun Marsh Salinity Control Gates

The Suisun Marsh Salinity Control Gates (SMSCG) were completed and began operating in October 1988. The first year of operation was used to test the gates, and official operation began in November 1989.

The facility consists of a boat lock, a series of three radial gates, and flashboards. The gates control salinity by closing during incoming tides to restrict the flow of higher salinity water from Grizzly Bay into Montezuma Slough. The gates open during outgoing tides to allow fresher water to enter Montezuma Slough and the marsh from the Sacramento and San Joaquin rivers. Operation of the gates in this fashion lowers salinity in Suisun Marsh channels and results in a net movement of water in Montezuma Slough from east to west (downstream). When Delta outflow is low to moderate and the gates are not operating, net water movement in Montezuma Slough is from west to east, resulting in higher salinity water in Montezuma Slough.

The SMSCG may begin operating in September to help meet salinity standards, and may continue operating through the end of May, depending on salinity conditions. The flashboards are removed and the gates raised to allow unrestricted movement through Montezuma Slough when the channel water salinity decreases sufficiently below the salinity standards, or at the end of the control season.

A DWR study evaluating the effects of the SMSCG on passage of chinook salmon was continued during water year 1999. The effect of various modified flashboard configurations on salmon passage was evaluated. The gates were operated only for the purposes of the study and not for salinity control during water year 1999. Additional information on the salmon passage study is available from DWR at the following address:

California Department of Water Resources
Environmental Services Office
3251 S Street
Sacramento, CA 95816-7017
Attention: Heidi Rooks
hrooks@water.ca.gov

Appendix E

Suisun Marsh Channel Water Salinity Standards for Water Year 1999

Compliance Stations and Monitoring Stations

Suisun Marsh channel water salinity standards for water year 1999 are specified by SWRCB Order WR 95-6 (SWRCB 1995). The SWRCB granted a waiver (Order WR 98-6, September 17, 1998) for meeting Suisun Marsh channel water salinity standards during water year 1999 at the five compliance stations (Table E-1). The waiver was granted to conduct an experiment to evaluate the effect of modified flashboard configurations on salmon passage at the SMSCG.

Two salinity monitoring stations, S-35 and S-97, did not have SWRCB salinity standards in effect during water year 1999. The names and locations of these two monitoring stations are listed in Table E-1.

Data from monitoring stations S-35 and S-97 have been included in this report to provide additional information on salinity conditions in the western portion of the Suisun Marsh during water year 1999. Data from the eleven other water quality monitoring stations in the marsh were not included in this report, but are available on request by contacting the address referenced in the "Background" section of this report (page 4).

Table E-1 Suisun Marsh salinity compliance and monitoring stations

<i>Station Identification</i>	<i>Station Name</i>	<i>General Location</i>
Compliance Stations		
C-2	Collinsville	Western Delta
S-64	National Steel	Eastern Suisun Marsh
S-49	Beldon's Landing	North-central Suisun Marsh
S-42	Volanti	Northwestern Suisun Marsh
S-21	Sunrise	Northwestern Suisun Marsh
Monitoring Stations		
S-35	Morrow Island	Southwestern Suisun Marsh
S-97	Ibis	Western Suisun Marsh

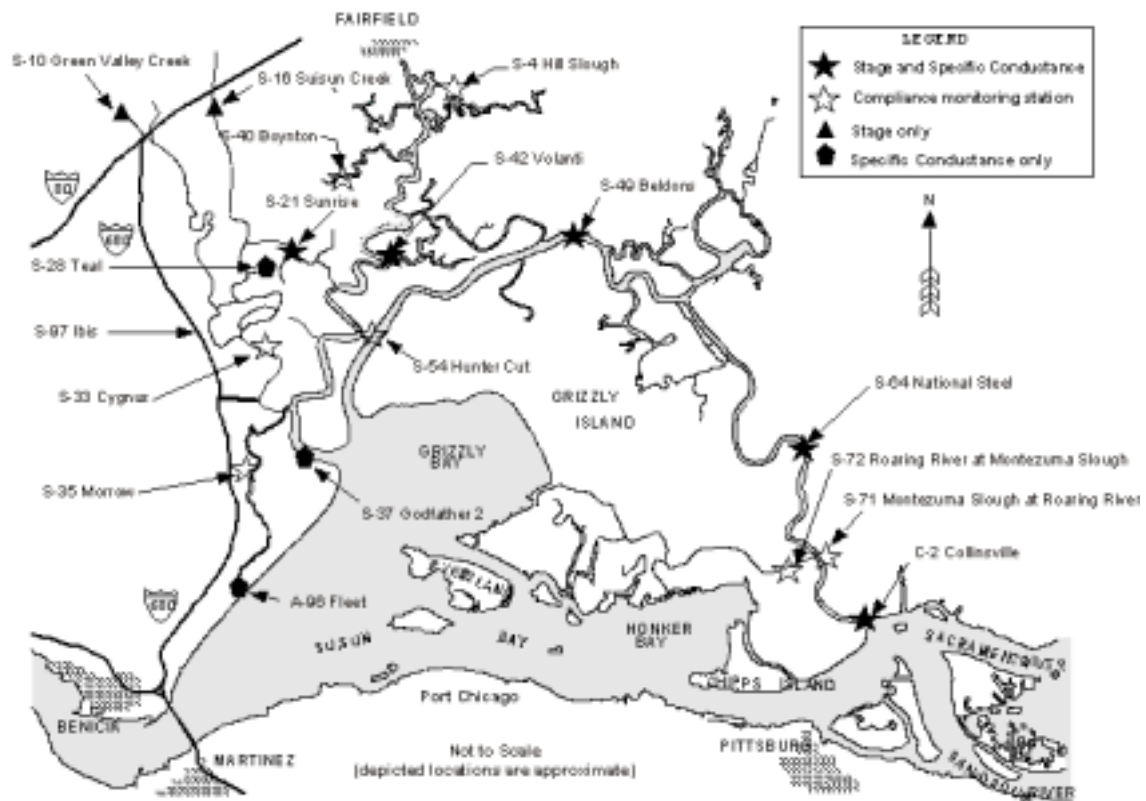


Figure E-1 Suisun Marsh compliance and monitoring stations, October 1998 through September 1999

Appendix F

Salt Marsh Harvest Mouse Monitoring in the Suisun Marsh During Water Year 1999

Background

The SMHM (*Reithrodontomys raviventris*) is endemic to Suisun Marsh and other marshes of San Francisco Bay (USFWS 1984). The species was listed as endangered by the USFWS in 1970 and by DFG in 1971.

The USFWS issued a Biological Opinion (opinion) in 1981 for the implementation of the *Plan of Protection for Suisun Marsh* (DWR 1984). The opinion requires DFG, on behalf of DWR, to manage 1,000 acres of state-owned lands within Suisun Marsh as preferred SMHM habitat. The opinion's long term goal is the management of 2,500 acres of SMHM habitat distributed across the marsh. In 1987, the DFG selected seven areas totaling 1,078 acres within the marsh (Figure F-1) to manage as SMHM conservation areas to fulfill the terms of the opinion (Wernette 1987). An additional eight areas, totaling about 1,500 acres, were proposed as conservation areas during 1999 to meet the 2,500 acre SMHM habitat goal.

Conservation areas surveyed in water year 1999 included the eight proposed conservation areas, two existing conservation areas where SMHM were not captured during surveys in 1998 (Hill Slough East and Joice Island), and one existing conservation area where excavation was proposed (Pond 1). In addition, traps were set briefly for training exercises at two existing conservation areas and one privately owned upland area. The survey areas, their status as conservation areas, habitat type, type of survey conducted in 1999, and acreages are listed in Table F-1. The locations of the fourteen areas are shown in Figure F-1.

In addition to the above trapping efforts, SMHM surveys were conducted at the Island Slough Pond 7 mitigation area. One hundred acres on Island Slough have been set aside and managed as SMHM habitat as mitigation for construction of the physical facilities mandated in the *Plan of Protection for the Suisun Marsh* (DWR 1984). The location of Island Slough is shown in Figure F-1.

Table F-1 Conservation areas where SMHM surveys were conducted during water year 1999

<i>Location</i>	<i>Status as conservation area</i>	<i>Habitat type</i>	<i>Type of survey conducted</i>	<i>Acres</i>
Benicia Industrial	Existing	Managed wetland	Training	46
Crescent	Existing	Managed	Training	67
Hill Slough West-Pond 1	Proposed	Managed	Training + regular survey	204
Rush Ranch	Private land	Upland	Training	?
Pond 12F	Proposed	Managed	Regular survey	114
Area 11	Proposed	Managed	Regular survey	about 100 ^a
Red House Road	Proposed	Managed	Regular survey	about 84 ^a
Area 12	Proposed	Managed	Regular survey	27
Hill Slough East	Existing	Tidal wetland	Regular survey	123
Joice Island	Existing	Tidal	Regular survey + additional survey	271
Pond 1	Existing	Managed	Survey before proposed construction	102
Hill Slough West Area-4A	Proposed	Managed	Regular survey	87
Hill Slough East Area-9	Proposed	Tidal	Regular survey	527
Goodyear Slough	Proposed	Managed	Regular survey	280

^a Area 11 and Red House Road are contiguous and together total 184 acres.

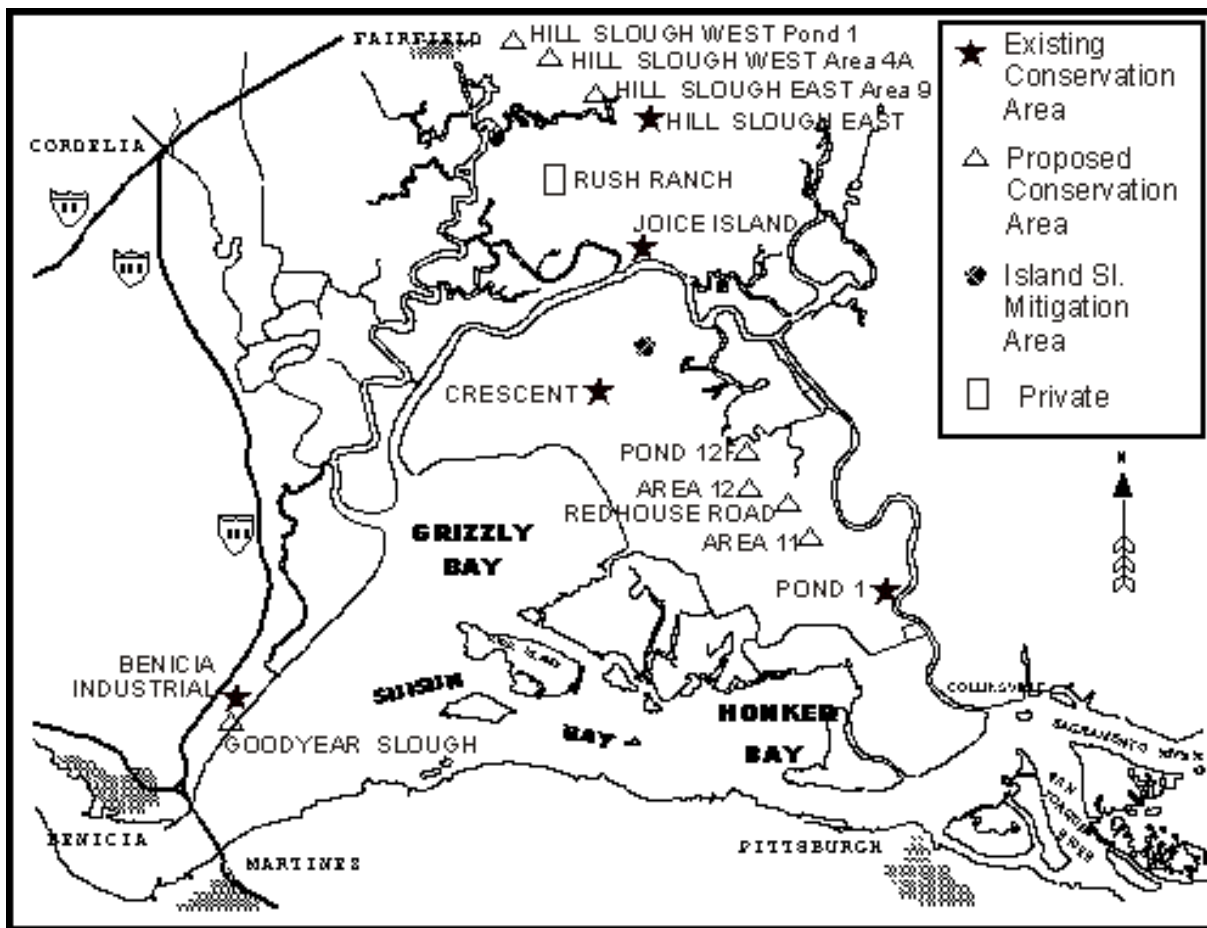


Figure F-1 Areas of Suisun Marsh surveyed for presence of salt marsh harvest mice during 1999

Data Collection Methods

The goal of the surveys is to detect presence of SMHM, and the normal survey protocol is to survey each selected area for three nights. However, due to high trap success in 1999, surveys were considered complete if the first night of trapping resulted in SMHM capture rates of 15% or greater. Thus, the number of trap nights varied from area to area. One hundred traps were set at each area, except during training exercises, when fewer traps were set.

A detailed description of the SMHM sampling methods is contained in the *Suisun Marsh Monitoring Program Reference Guide, Version 1* cited in the "Background" section of this report. The guide is available on-line at <http://iep.water.ca.gov/suisun>.

Appendix G

Waterfowl Surveys in the Suisun Marsh during Water Year 1999

Background

The Suisun Marsh is an important wintering area for waterfowl along the Pacific Flyway. Waterfowl commonly wintering in Suisun Marsh (DWR 1984) include

- northern pintail (*Anas acuta*);
- mallard (*Anas platyrhynchos*);
- American wigeon (*Anas americana*);
- green-winged teal (*Anas crecca*);
- northern shoveler (*Anas clypeata*);
- ruddy duck (*Oxyura jamaicensis*);
- canvasback (*Aythya valisineria*);
- white-fronted goose (*Anser albifrons*); and,
- Canada goose (*Branta canadensis*).

Migrant waterfowl begin arriving in the marsh each year during August. The highest waterfowl counts usually occur in October. Waterfowl numbers in the marsh typically remain fairly constant from October through December and then usually decline in January.

Data Collection Methods

The DFG conducted semi-monthly aerial waterfowl population surveys in the Suisun Marsh from September 1998 through January 1999. Census estimates (DFG unpublished data) were provided to DWR in digital and tabular form.

Waterfowl surveys in the Marsh were flown 100 to 150 feet above the ground at speeds of 90 to 105 miles per hour (USFWS 1987). Observers estimated the numbers and species composition of waterfowl within one-eighth of a mile of either side of the plane. Data reported were the total estimated numbers observed during the survey. Short-term factors such as weather and movements by waterfowl flocks in addition to longer-term factors, such as land use changes, preclude use of annual census results for determining absolute population size. The aerial survey results are generally useful for identifying long-term trends in approximate numbers of waterfowl in the marsh.

Contents

List of Preparers	1
Introduction	2
Background	4
Data Summary	6
Hydrologic Conditions	6
Suisun Marsh Salinity Control Gates Operations	9
Water Quality Conditions	10
Wildlife	14
Vegetation	17
Maintenance	17
Monitoring Station Maintenance	17
Distribution System Maintenance	18
References	19
Appendices:	
A. Methodology for Determining Water Year Hydrologic Classification for the Sacramento Valley	20
B. Sacramento Valley Water Year 1999 Hydrologic Classification	21
C. Method for Calculating the Net Daily Outflow Index	22
D. Purpose and Operation of the Suisun Marsh Salinity Control Gates	24
E. Suisun Marsh Channel Water Salinity Standards for Water Year 1999	25
F. Salt Marsh Harvest Mouse Monitoring in the Suisun Marsh During Water Year 1999	27
G. Waterfowl Surveys in the Suisun Marsh during Water Year 1999	30

